International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

A Conceptual Model Design of Seaweed Agroindustry Logistic System: A case study in the South Sulawesi, Indonesia

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Abstract

The objective of this research is to design a conceptual model for seaweed agro-industry logistic system through a case study in the South Sulawesi Indonesia. Two stage approaches were used to develop the conceptual model. The first stage employed a system analysis in which an entity approach was employed. The second and final stage was a graphical conceptual modeling design where Business Process Modelling Notation 2 (BPMN 2.0) was used. The existing logistic system in the study area was verified and validated using the conceptual approach.

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The system analysis stage reveals a comprehensive yet interrelated logistical system of seaweed agro-industry in the study area such as entity structures, responsible stakeholders, system inputs, system processes (process attributes, capabilities, performances, products, by-products, and services), system outputs, roles, system objectives and missions, threats, opportunities, resources, controls, physical constraints. Using the notation in BPMN 2.0, the study developed a graphical representation of the working logistical system in the area. This model produces a graphical conceptual model of seaweed agro-industry logistic system in the South Sulawesi that describes the system behavior.

Keywords: Business Process Modelling Notation; Conceptual Model; Logistic System; Seaweed Agroindustry; System Entity.

1. Introduction

A logistics system is a system of goods flowing from one source point to one or more consumption points in order to supply the needs of consumers or institutions. [1] argue that a logistics operation consists of an efficient logistics management system to provide goods with the right number, place, order and timing efficiency which eventually will reduce the operational logistical costs. In order to achieve this, understanding the current working logistical system as well as developing and improving the design a logistics system are the utmost importance.

The initial stages in the design, engineering and system development are building a conceptual model of the logistics system (as a business process) to know the current working system and its behavior. A conceptual model, in this case, facilitates the development and design of the system, as well as providing a baseline information in analyzing, designing and developing other related models such as mathematical models, geographic information models [2], and basic simulation models. In addition, the conceptual model also [3], assists involved stakeholders in the decision-making process for any logistical issues, [4] clarifies the role and relationship of stakeholders in the system, helps the development of information systems and facilitates the understanding of the complex logistics systems [3].

According to [5], a conceptual model is a graphical representation a real-world system in form of a model which describes the interaction of inputs, processes, objectives, matters affecting the system, assumptions and provides the implications of the model. A graphical conceptual model visualizing the behavior of a real system can be used as a foundation in system simulation, implementation, evaluation, and improvement. One of the methods in the conceptual model that can be used to describe a system is a business process model [6, 7]. For example, the conceptual model can describe a seaweed logistics system that seamlessly transports seaweed products from one stakeholder to another to fulfill the demands of consumers.

According to [8], Indonesia is the world's second largest producer of seaweed after China contributing 34.6% or 9,298,474 tons of the total world seaweed production. South Sulawesi is Indonesia's largest exporter and seaweed producer with a 28% contribution to the overall national production of 10.2 million tons. Approximately, as much as 85% is exported in the form of dried seaweed and 15% processed first into powder and chips. As a result, most of the seaweed profits are obtained by importing countries through diversification and value added products. The Indonesia government has been supporting the development of seaweed logistics system through the Presidential Regulation No.26 / 2012 regarding The Development of the National Logistic System (SISLOGNAS). The government also has included seaweed commodity in the national warehouse receipt system through Law No.9 /2011 regarding Warehouse Receipt System, which was initially implemented in the South Sulawesi. In order to understand the current development of seaweed industry in Indonesia, this paper was aimed to study and design a conceptual model of a seaweed logistics system in Indonesia using a case in the South Sulawesi.

The development of seaweed logistics system in the South Sulawesi carried out by the national and local governments requires a clear abstraction and business process flow as well as to understand the actual logistics system behavior. A better logistics system can improve the coordination of business processes among stakeholders and eventually increase the export of higher added value processed products instead of exporting raw seaweed materials. Based on this, the business process design on seaweed logistics system is needed which can be used to solve problems of efficiency and responsiveness of seaweed logistics in the South Sulawesi such as uncertain availability and demand of raw materials, high transportation costs, and unscheduled transport times. The conceptual model of the business process of seaweed agro-industry logistics system can be developed in form of a conceptual diagram containing activities and behavior of the seaweed logistics (interoperability) business system. As such, the activities and behaviors of the system can be determined through inputs, processes, outputs, and attributes [9]. In general, this particular design is important in the early stage of seaweed logistics system design.

The outcomes of the research carry a significant importance as the study and development of seaweed agro-industry system has been relatively overlooked. Generally, the direction in seaweed agro-industry research currently deals with technology and engineering processes. Several studies on seaweed management and related systems had been conducted by [10,11] who examined the social and environmental sustainability, Reference [12] handling availability of seaweed supply, Reference [13] risk management of seaweed supply chain and [14] on the development of Indonesian seaweed business. This research focuses on developing a novel conceptual modeling of seaweed agro-industry system with the main interest in the logistic field. This focus set it apart from other studies which can contribute significantly in the scientific development of seaweed agro-industry. Specifically, the study aims to design a conceptual model of seaweed agro-industry logistics system in the South Sulawesi.

2. Research Methods

A system engineering and development is a cycle that begins with an idea stage, needs analysis in the form of a system entity, development of a process model (in this case logistics as a business process), implementation (to verify and validate the system), improvement stage, and back to Stages of ideas [9]. This study follows the stages of the system engineering ideas described in the research phase in Figure 1.

System analysis is conducted to identify and know the necessary needs in designing conceptual model of a seaweed agroindustry logistic system. This analysis is done through needs analysis with the representation approach of the system in the form of the system entity.

This research uses a conceptual business process model approach to design a seaweed industry logistics business system with South Sulawesi case study. The first stage is analysed in the form of representation of system entity. The second stage is modelling seaweed agro-industry system using BPMN 2.0 diagram to find out system behaviour and conceptually verify.

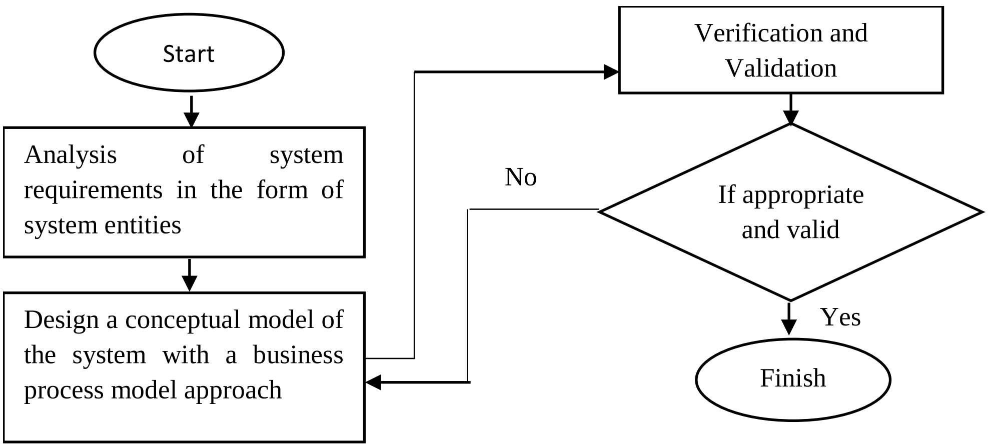


Figure 1: Research stages (adoption of Wasson 2015)

2.1. System Analysis

[9] represents a system in the form of a composite entity system consisting of unwanted or unwanted inputs and outputs so that controls of unwanted inputs and outputs can be made; Processes that contain performance attributes, products, by-products; Stakeholders and their respective roles, rules, resource constraints, system missions, opportunities, threats and feedback. Figure 2 is a representation of the system representation as an entity.

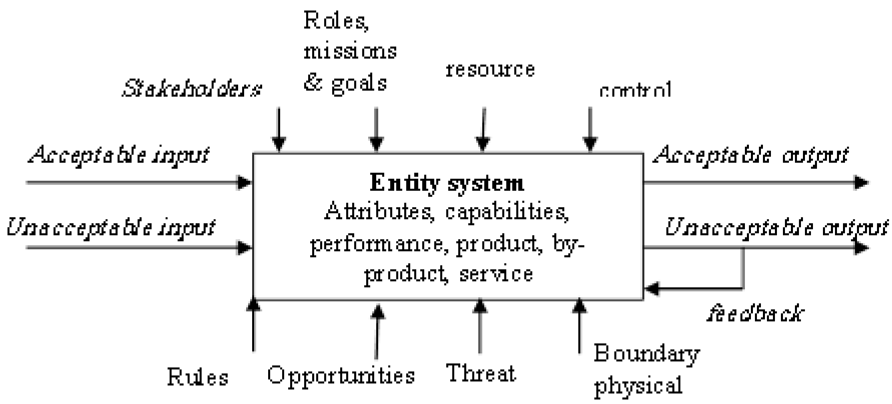


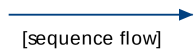
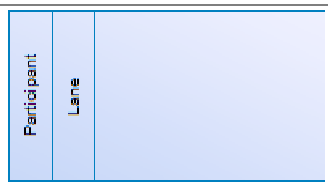
Figure 2: Representation of systems in the form of entities [9]

The process of a business system is analogous to a system entity that represents top-level systems, subsystems and other derivatives. This system entity has a limited ability to process inputs into outputs with certain performance measures. While processing inputs into system output is influenced by factors from its operating environment such as stakeholders and their respective roles, rules, mission systems, opportunities, threats, controls and resources. The resulting output can be either an appropriate or inappropriate output that will give a reciprocity to the system.

2.2. Conceptual Design System Using Notation of Business Process Model Version 2

After the needs analysis is done, the next step is to design conceptual model to know the behaviour of a logistic system of seaweed agroindustry. This paper uses the conceptual diagram BPMN 2.0 as a conceptual representation of system design. BPMN 2.0 is a standardised graphical notation used to make it easier to understand not only actors on a system but also technical analysis and development that have a particular role in configuring and overseeing the implementation of a system [15].

Table 1: Explanation of each notation in BPMN 2.0 [15].

Flow Object		
Event	Shows the events of an activity starting from *start, intermediate, end*	
Activity and decomposed process	Shows the activities performed by a business process, sign + signifies decomposed activity (has a process of explanation /derivation therein)	
gateaway	Shows a branching or selection path such as *forking, merging, joining*	
Connecting objects		
Sequence Flow	Shows the sequence of activities performed in a process	
Message Flow	Indicates the flow of messages that occur between actors of the process	
Association	Shows the input and output required by an activity	
Swimlanes	Presenting actors of an activity and group	

BPMN uses a process-oriented approach to system modelling. BPMN makes it possible to visualise a large collection of process and communication paths between processes [16]. Notations on the type 2 business process model consist of the prefix, intermediate, and the end of the modelled system event, specific activities, gateway rules, data objects, and input and output flows in an activity [15]. Table 1 describes the function of each notation in BPMN 2.0. The conceptual model design is done with the help of Power Designer 2016 software. The software provides enterprise-scale business model libraries solutions with system capabilities designed to be usable by developers of engineering multi-disciplinary systems of science, producing powerful conceptual system development reports And easy to redevelop [15].

2.3. Verification and Validation

Verification is done by checking the suitability of the conceptual model designed with the system concept [17, 18]. This compliance can be checked using Power Designer 16.5 software with 0 error and 0 warning marks when BPMN 2.0 is executed for system conceptual verification. Conceptual validation is done by examining the conceptual model results with system requirements that have been designed in the system analysis. Validation and verification are conceptually relevant and can be done if a system needs analysis or expert opinion study has been conducted, as well as conceptual review through the relevant scientific literature before abstracting on the conceptual model [19, 20, 21, 22].

2.4. Data collection

Required data on system and design analysis is obtained from field surveys and experts (primary data) and tracking information from scientific literature related to systems development, logistics systems and seaweed agroindustry development (secondary data). Every part of the business process is designed based on scientific literature and field surveys. Data and information were collected from May-December 2016 in South Sulawesi.

2.5. System Limitations and Assumptions

The system studied in this conceptual model has limits ranging from post-harvest to logistics activities derived seaweed agro-industry products. Derivative products are restricted to the derivative products of seaweed processing which are produced in South Sulawesi, namely Eucheuma seaweed.

3. Results

3.1. System Requirement Analysis

Based on a field study in South Sulawesi and according to [1] states that logistics is a flow of goods, information and money consisting of procurement, plant site logistics and product distribution logistics. Based on the identification system in South Sulawesi and the opinion, this research divides the logistics system into three subsystems.

3.1.1. Subsystem Procurement Entity

Based on field observation and literature review [23, 24, 13], this subsystem has 5 main processes ie post harvest, raw material transportation, quality control, raw material storage, raw material procurement by collectors and Handover of raw materials. The result of system analysis of subsystem entity is tabulated in Table 2. According to [23, 24, 25], Reference [25] the existing rules when the operation of the sub-procurement entity is the rules of seaweed harvest, the quality and quanti ty according to the contract, the proximate and organoleptic rules of seaweed on quality control, as well as the rules of storage and transportation in the form of material handling, And moisture. Possible opportunities are increased demand for seaweed, the fulfilment of quality and quantity of raw materials according to the contract agreement, and the opportunity of inclusion of seaweed as one of the commodities in Warehouse Receipt System [23, 24].

Table 2: Result of analysis of subsystem of procurement of raw materials

Process, input dan output		
Process/system entity	**Input**	**Output**
Post-harvest	wet seaweed	Alkali Treatment Carrageenan (ATC) chips, ATS chips, semi-refined carrageenan (SRC), refined carrageenan (RC), processed household
Transport of raw materials	Number of seaweed, transportation mode, travel time, transportation cost	Seaweed arrives at the consumer on time, seaweed quality is not changed/damaged
Quality control	Quality of seaweed according to the standard	Seaweed has a quality
Storage of raw materials	Number of raw materials, size of storage space	Raw materials are well stored
Procurement of seaweed raw materials by industry	The number of requests, the location of demand, the amount of inventory, the price of seaweed, the source of the inventory	Demand and quantity of industrial raw materials per period
The handover of raw materials	Handover time, transaction data receipt of raw materials	Raw materials are available on time, a number of raw materials received and according to type

Stakeholders and their respective roles	
Stakeholders	Roles
Seaweed farmers	Conducting post-harvest process
Collector/Village Unit Cooperative (KUD)	Buy seaweed, maintain quality and make the process of transportation
Exporter of raw materials	Buy seaweed from KUD and do the export process of raw materials
Parts of procurement processing industry	Buy and check the quality of seaweed
Threats and Controls	
Threats	**Controls**
Seaweed exposed to rain, dirty on the post-harvest process	Drying with a shield/roof, keeping from contamination with soil/sand, harvesting is done in the morning
Unavailability of transportation fleets, as well as disruption when transporting raw materials	Scheduling and planning the transportation of raw materials
The amount of dried seaweed that does not meet SNI standards such as high moisture content, dirty, and defect during the process of procurement of raw materials	Conducting training on harvesting, drying, storage and logistics operations of procurement of seaweed and socialisation of SNI
Product nonconformity with contract	Check before delivery

3.1.2. Entity internal logistics subsystem (plant site)

The internal logistics subsystem is the processes (system entities) that occur in the dry seaweed processing industry. Based on field observations and [26], this subsystem consists of three main processes: raw material storage, production process and packaging of processing products (Table 3).

Table 3: Analisis sistem pada entitas subsistem logistik internal

Input, Proses dan Output		
Proses (entitas sistem)	**Input**	**Output**
Raw material storage	Number of dried seaweed, quantity, seaweed product, storage time, raw material warehouse	Industrial demand is available, raw materials are well stored
Production process	Number of dried seaweed, number of auxiliary materials for every process of product, labour, machine and production equipment, amount of energy materials (electricity, diesel & gasoline) and production cost	Seaweed dried 35% moisture content, Seaweed processed products: ATC chips, ATS chips, semi-refined carrageenan (SRC), refined carrageenan (RC), home industry
Product packaging	Plastic polyethene, polypropylene, and label packaging	Processed products packed

Stakeholders and their respective roles	
Stakeholders	**Roles**
Warehousing of industrial raw materials	Conduct storage and maintain the quality of raw materials
Parts of the production process	Producing seaweed into processed products such as ATC chips, ATS Chips, semi-refined carrageenan (SRC), refined carrageenan (RC), home industry products (dodol seaweed, etc.)
Packaging section of raw materials	Packing processed products of seaweed
Quality control section	Maintaining the quality of seaweed processed products
Research and development section	Conducting research and product development
Part of production planning	Perform production planning

Threats and Controls	
Threats	**Controls**
Non-conformity of temperature and humidity conditions of storage, buildup, expiration, gross decreased quality due to shelf life, and lack of raw materials, and coding errors in packaging	Controlling temperature and humidity, avoiding contact with flooring, adjusting production schedule with raw material availability, maintaining raw material quality with foreign material content <5%, raw material standard fulfilled, the water content of raw material 30 - 35%. Ensure and check packaging code
Damage of grinding machine and mismatch of process conditions	Perform process control and process engine maintenance periodically

Processes in this subsystem have rules such as Law Number 9 Year 2006 regarding Warehouse Receipt System, Minister of Trade Regulation no 26 / M-DAG / PER / 6/2007 about goods that can be stored in warehouse in warehouse receipt , The rules of the Ministry of Marine Affairs and Fisheries, and the standard processing of seaweed products based on SNI.

Opportunities that may occur during operations are investment opportunities, high demand for processed seaweed products, new product development opportunities and opportunities for technology development process of processed seaweed processing.

Table 4: The result of entity logistic subsystem analysis of seaweed processed product (*finish good*)

Input, process and output		
Process (system entity)	**Input**	**Output**
Storage of products	The number of warehouse facilities, storage space, and stored products	Products are available when needed
Product transportation	Type, capacity, and quantity of transport, product of number, distance of product receiving location	Central distribution location, the product arrives at the consumer
Product marketing	Product sale price, sales amount, Sales location	Marketing strategies and products sold
Export products	The number of seaweed exporters, Demand for seaweed	Product accepted
Packaging products in distribution	The right product packaging	The product is packed well

Stakeholders and their respective roles	
Stakeholders	**Roles**
Warehousing of finished products	Operational warehousing of finished products
Control inventory	Control product stock / inventory
Quality control	Control and supervise product quality during the logistics process of finished products
Product marketing	Conducting activities and designing marketing strategies of seaweed products
Transportation	Transport seaweed to the end consumers and export products
Export	Conducting activities and export operations of processed products of seaweed

Threats and Controls	
Threats	**Controls**
Low warehouse performance impacts on product quality, cost, and inventory planning	Perform efficient management of warehouse and inventory operations, as well as product transportation processes
Consumer's negative response to the product	Ensuring consumers receive the product on time, quantity and quality.
Export products do not meet export standards	Apply product standards according to destination country of export

3.1.3. Entity logistics subsystem processed seaweed products (finish good)

This subsystem is a subsystem with physical limits from warehousing of finished products until products are distributed to exporters and end consumers. The processes (entities) contained in this subsystem are product storage, product transportation, export and distribution packaging [1]. Based on [1, 26] entity subsystem analysis are tabulated in Table 4. The results of the analysis of the rules in this subsystem are the rules on storage conditions such as temperature and humidity, the rules on the operation of product transportation (the number of trucks, product arrangements, and truck container conditions), seaweed-derived product quality at the time of marketing and Transportation is the limit of contamination of lead (Pb) in seaweed by 0.001 percent (10 ppm) and Arsenic (As) maximum 0.0002 percent (2 ppm), as well as the provisions of BSN (The Indonesian Standardization Body) on seaweed products.

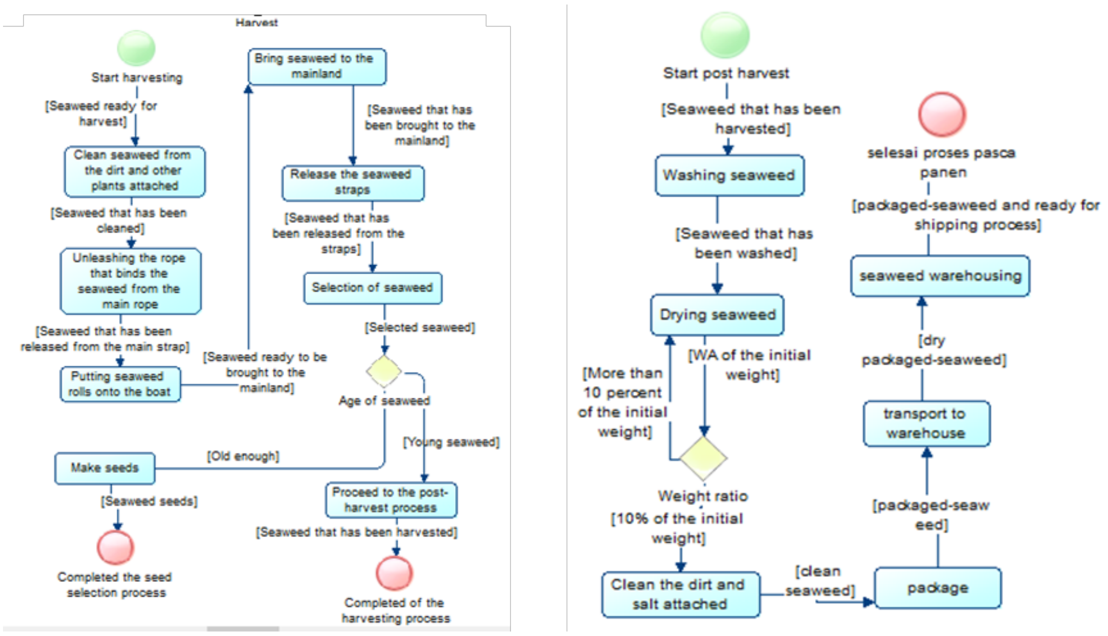


Figure 3: Post-harvest business process model

Opportunities that exist in this subsystem is derived seaweed products have high added value and potentially improve the position of Indonesia in the world market seaweed market competition through increased efficiency and responsiveness of logistics system of finished products until the product can reach to the final consumer both domestically and export. Improving the welfare of farmers and small and medium enterprises (UKM) seaweed processing due to the wide market availability and the efficiency of the logistics process.

3.2. Conceptual Design of Business Process Logistics System of Seaweed Agro Industry Using Notation of Business Process Model 2

The conceptual model builds on the results of the previous system analysis with the notation of the business process 2.0 model. Based on system analysis, entity logistic system of seaweed agroindustry with a case study in South Sulawesi consists of three subsystems namely raw material procurement, internal logistics and logistics of the finished product. The conceptual model of this part of the result will be explained on the basis of that subsystem.

3.2.1. Subsystem harvesting, procurement, quality control of storage, transportation of raw materials

Based on field observation and literature review [23, 24] raw material procurement subsystem consist of harvest and post harvest, raw material transportation, quality control, raw material storage, seaweed material procurement for the industrial production process and handover raw material. Figure 3 shows the conceptual model (business process model) for the harvest and post harvest process.

The process of harvesting is a process that is in the swimlane (stakeholder) seaweed farmers. This process begins with a harvest process with the main activity releasing the seaweed from the binder and bringing to the ground for a post-harvest process with the main activity of clearing the seaweed and drying it. Seaweed that has been purchased is stored in the cooperative and carried out quality control to maintain the quality of dried seaweed during the storage period.

Furthermore, the raw material transportation process. This process is an activity undertaken by collectors or cooperatives that are carried out by transporting raw materials from farmers to exporters and industries. The process begins with loading (loading) raw materials to the carrier fleet and sends to exporters and industries for handover process.

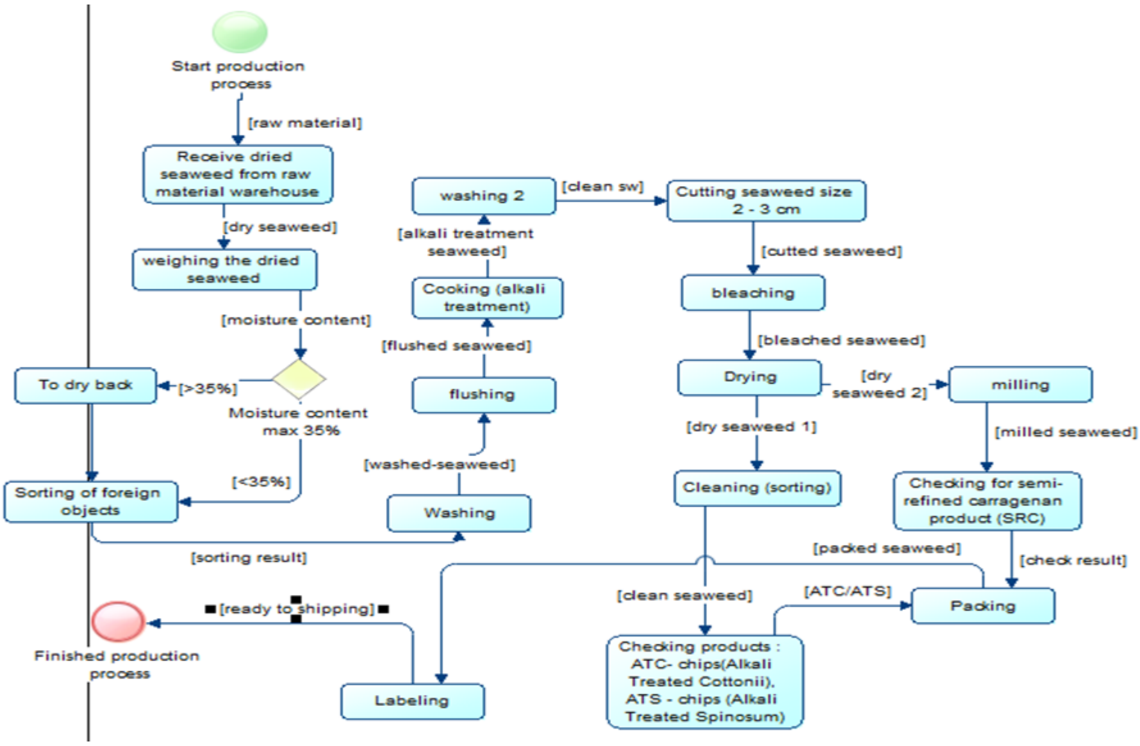


Figure 5: Business processes for production planning, production process, research and development, quality control and warehousing of finished products

The ordering of raw materials is done by the procurement of raw materials of the seaweed processing industry to meet the needs of the production process. This process is done by ordering raw materials and receiving the delivery confirmation from cooperatives or collectors. After the transport process is done, the procurement department of the industry hand over by checking the raw material transport files and check the quality of seaweed received. If not according to an agreement. Industry can make complaints which can then be feedback to cooperatives for evaluation and follow-up. Another form of examination that is not in accordance with the agreement is to give a decrease in seaweed prices of Rp 1000, - /kg.

3.2.2. Internal logistics subsystem

The internal logistics subsystem consists of 6 lanes, namely raw material storage, quality control, production, research and development, production planning, and packaging section. The main process in this subsystem is the production process of seaweed derived product. Storage of raw materials is done after the handover process done on the previous subsystem. Raw materials are stored and quality control is carried out during storage until there is demand from the production department to prepare the raw materials. The quality control section evaluates each quality control activity undertaken.

The next business process is production that is done based on put put system from the research and product development and production planning. The products to be marketed are first designed by the product development section and an estimate of the type of product and the amount of production that the industry must perform for a period. After the production process then carried out the packaging process of primary and secondary products. Figure 5 is a business process for production planning, production process, research and development, quality control and product packaging [1, 26].

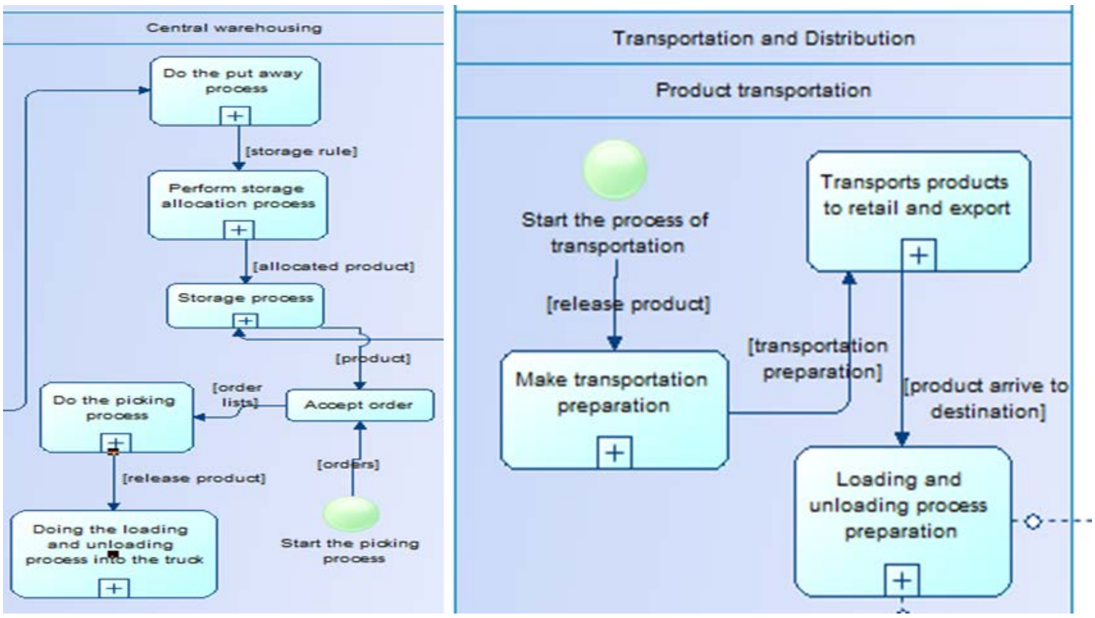


Figure 6: *Lane* main process logistics business processed seaweed products

3.2.3. Logistic processing subsystem of seaweed products (finish good)

This subsystem consists of eight-lane business processes consisting of distribution packaging processes, warehouse and inventory operations, quality control, marketing, transportation and distribution, consumers consisting of retailers and end consumers. The main activity of this sub-system lies in the lane of the warehouse business process of the finished product and the distribution process as shown in Figure 6. The product will be stored in the warehouse and carried out product quality control and warehouse operational process until the product is ready to be loaded into the distribution fleet. Fleet distribution will make the transportation process to consumers and exporters to the handover process. The handover process is carried out to check the deal on the quantity and quality of the received product. If not to order and consent of consumer and exporter may file a complaint which then becomes material of evaluation by product distribution system [1, 23, 24]. When quality is not appropriate, the buyer can lower the purchase price of seaweed.

3.3. Verification and Validation

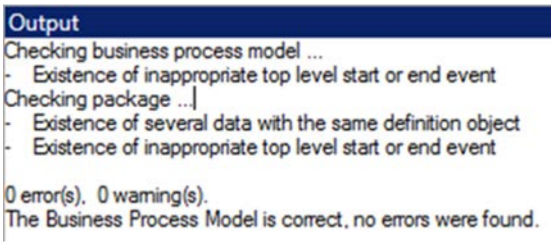


Figure 7: Result of verification of conceptual model of business process of logistic system of seaweed agroindustry with case study in South Sulawesi

Verification of the model here is done by checking the suitability of the model designed with the concept of the system in general (conformity with the concept of system entities) with the help of Sybase Power Designer software [15]. The results of the model verification are shown in Figure 7. The 0 error and 0 warning results indicate that the model designed has been in accordance with the concept of the system entity.

Validation is done by checking and adjusting business process models designed with system analysis results. The results of the examination of the validation process are tabulated in Table 5.

Based on the results of verification and validation of a conceptual model of business process logistics system seaweed agroindustry can be concluded that the conceptual model of the business process developed has been verified and validated. This means that abstraction in the form of this conceptual model can be used as a basis for the development of the next system model on the seaweed agroindustry logistics system.

4. Conclusion

This research developed a conceptual model of seaweed agro-industry logistics system based on a case study in the South Sulawesi as a form of business process. The conceptual model of the business processes was divided into three subsystems namely raw material procurement, internal logistics and logistics of finished products. The verification and validation of the conceptual model showed that the model was conceptually feasible and could be used for further system development. Based on the findings, future research can be directed toward studies related to efficiency analyses on each subsystem/system entity, potential mapping , and institutional relationship of seaweed agroindustry development. Furthermore, studies on the uncertainty of seaweed agroindustry development can also be conducted in the form of adaptive and dynamic analyses coupled with soft computational approach. This approach will provide a detail information in designing an adaptive and more responsive seaweed logistic system.

Table 5: Results of the validation check conceptual model of the logistics system agro-industry business processes seaweed.

Subsystem	System Entity/process	Checking Conceptual Validation
Procurement of raw materials	Transport of raw materials	It's in the model
	Quality control	It's in the model
	Storage of raw materials	It's in the model
	Supply of raw materials by industry / exporter	It's in the model
	The handover of raw materials	It's in the model
Internal logistics	Storage of raw materials	It's in the model
	Production process	It's in the model
	Product packaging	It's in the model
Logistics of finished products	Storage of products	It's in the model
	Product transportation	It's in the model
	Product marketing	It's in the model
	Export products	It's in the model
	Packaging distribution	It's in the model

Acknowledgements

We would like to thank the farmers, collectors and seaweed processing industries located in South Sulawesi, as well as the related institutions of data in this study. The study is funded by the Ministry of Research, Technology and Higher Education of the Republic of Indonesia in 2012.

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